In the Specification:

On page 3, please rewrite the second full paragraph as follows:

In Figure [~~1~~] 1A, an actuating force applied to the mirror 1002 from the actuating surface 1012, near a point A, draws a free edge of the mirror toward the actuator surface 1012 in the direction of the arrow shown at A. The mirror 1002 pivots about the Y-axis at the gimbals 1004 and 1006 such that the mirror at point B is raised with respect to the actuator surface 1012 as shown by the arrow at B. In the other axis, an actuator on the actuator surface 1012 near a point C draws another free end of the mirror in the direction of the arrow shown at C. The mirror 1002 pivots about the X-axis at the gimbals 1008 and 1010 such that the mirror at point D is raised with respect to the actuator surface 1012 as shown by the arrow at D. Single axis devices are also known for providing tilt about a single axis only. The actuator devices may employ electro-static, electromagnetic piezo-electric and mechanical actuator forces.

On page 4, please rewrite the first full paragraph as follows:

Figure [~~1A~~] 1B depicts a plurality of optical switching mirror assemblies 1000. One commercially available example provides a 64 by 64 MEMS optical switch module having an operating temperature range of 5 to 70 degrees Centigrade, listed mirror switching time of 20 ms, with a power dissipation consumption of 15 watts. Insertion loss is 6 dB max (e.g. 75% losses); optical return loss is 30dB, and cross channel isolation is 50dB. Optical power transmission is limited to 31 milliwatts per port. In the particular example of Figure [~~1A~~] 1B, each device 1000 is centered with respect to rows 1014 and columns 1016. Such an arrangement provides a poor packing density for each device leaving a low mirror area to total area ratio. Optical switching system, arrays of as few as two mirrors up to as many as 1024, or more, separate mirror elements may be required to be operating in an optical network switching hub.

On page 4, please rewrite the second full paragraph as follows:

One problem with the device shown in Figures [~~1 & 1A~~] 1A and 1B is that the mirror is surrounded mainly by air and lacks any conductive path to remove heat. This is one reason that conventional MEMS mirror devices are limited to low power, e.g. only 31 mw in the above example. Since the reflective surface of each mirror is typically limited to about 96 to 98% reflectivity, 2 to 4% of the light energy reaching the mirror may be absorbed by the mirror substrate or scattered, thereby heating the mirror substrate and the surrounding elements.

On page 8, please rewrite the second full paragraph as follows:

The invention provides a method and apparatus for directing a radiation beam in a desired direction. There is provided a movable member supported for movement by a fixed member and movable member has an optical element, [~~e.g~~] e.g., a fiat mirror fixedly attached thereto. In one embodiment the mirror [~~scan~~] scans a radiation beam incident thereon in one plane. In a second embodiment, the radiation beam is scanned in two mutually perpendicular planes. A magnetic element having a north and a south magnetic pole is fixedly attached to the movable member. A magnetically permeable stator element that is stationary with respect to the movable member and the magnetic element is placed in the field of the magnetic element such that the stator element and said magnetic element mutually generate a magnetic traction force between them. A current coil is wound around a portion of the stator element and a current driver is provided for driving a current in the current coil. The current induces an electromagnetic force in the stator element and the electromagnetic force acts on the magnetic element for controlling movement of the optical element with respect to the fixed element. A radiation beam source may be directed onto the movable mirror surface and scanned by the movement of the mirror to direct the radiation beam in a desired propagation direction.

On pages 9 and 10, please rewrite the Brief Description of the Drawings section as follows:

Fig. [~~I~~] 1A is a prior art top view of a moveable, optical beam mirror assembly.

Fig. [~~IA~~] 1B is a prior art view depicting a portion of an array of movable optical mirrors.

Fig. 2 is a prior art perspective view of a two-axis laser scanning system.

Fig. [~~3~~] 3A is a cross section view of a preferred embodiment of the invention.

Fig. [~~3A~~] 3B is a single axis steering device.

Fig. 4 is [~~an second side~~] a bottom view of the embodiment of Fig. [~~3~~] 3A.

Fig. 5 is a partial cross section view of the embodiment of Fig. [~~3~~] 3A, the coils being omitted for clarity.

Fig. 6 is a [~~lower end~~] bottom view of the structure of Fig. 5.

Figs. 7A, B, C, and D are partial cross section views of embodiments with different magnet ring configurations.

Fig. 8 is a diagrammatic [~~plane~~] plan view of the lower end of the stator and coil windings of the embodiment of Fig. [~~3~~] 3A.

Fig. 9 is a schematic of the flux circuit of the embodiment of Fig. [~~3~~] 3A.

Fig. 10 is the cross section of Fig. [~~3~~] 3A, illustrating the magnetic forces of the embodiment with force diagrams.

Fig. 11 is a lower end view of an array of the devices of Fig. [~~3~~] 3A, illustrating the packing arrangement for best area density yield.

Fig. 12 is a cross section view of a single magnet embodiment with a core magnet of vertical orientation and a dual axis stator and coil assembly.

Fig. 13 is a horizontal section view of the device of Fig. 12, showing the dual axis coil assembly in plan form.

Fig. 14 is a cross section of the device in Fig. [~~3~~] 3A, configured with a capacitive position sensor.

Fig. 15 is a diagrammatic cross section view of an embodiment of the invention configured with an image conduit connecting to remote light source and position sensor.

Figs. 16A, B and C are detailed views of portions of the embodiment of [~~Figs. 15A, B and C~~] Fig. 15.

Fig. 17 is a side elevation of yet another embodiment of the invention incorporating a right angle light source, beam reflector, and optical position sensor mechanism.

Fig. 18 is a single channel representation of a fiber-to-fiber optical link control system, illustrating beam splitter optical position sensors as components of the system.

Fig. 19 is a single channel representation of a fiber-to-fiber optical link control system, illustrating fiber tap optical position sensors as components of the system.

Fig. 20 is a matrix array of two banks of deflectors of the invention, providing an optical link between multiple fibers.

Fig. 21 is a steering device having mechanical position sensors.

Fig. 22 is an electronic servo controller for driving a control current to the stator coils. Fig. 23 is a radiation scanning system for scanning two and three-dimensional objects.

Fig. [~~24~~] 24A is a radiation scanning system having a radiation source attached to the movable element.

Fig. [~~24A~~] 24B is a radiation scanning system having a flexible beam conduit attached to the movable member for directing a beam exiting from the conduit.

On page 11, please rewrite the second full paragraph as follows:

Referring now to Figs. [~~3-7~~] 3A - 6, there is illustrated the general layout of a preferred embodiment of the invention. Fig. 3 depicts a sectional view showing a two axis optical beam steering apparatus 5 in the general form of a ball and socket assembly. It is comprised of a movable member 10 in the form of a spherical or ball portion having an outer bearing surface 11 supported in a fixed member 40 that includes a spherical raceway or socket 20 for forming a seat in which the movable member 10 is movably supported for rotation with respect thereto. The fixed member 40 in the present example comprises a thin flat plate but may have other configurations. As shown in Fig. [~~3~~] 3A, the movable member 10 and the fixed member 40 each includes a first side 6 and an opposing second side 8. The fixed member 40 is configured to provide free access to the movable member 10 on each of the first side 6 and the second side 8.

On pages 11 and 12, please rewrite the paragraph that joins pages 11 and 12 as follows:

The sectional view of Fig. [~~3~~] 3A is taken through a second equatorial plane of the spherical or ball member 10 that is perpendicular to the surface 30. A radial center 32 of the spherical or ball member 10 is shown on the surface 30 and represents an axis of rotation for the spherical or ball member 10. An optical beam or ray 34 incident on the mirror surface 30 at an angle β with respect to, e.g. a vertical axis V, is reflected at a reflection angle of $\beta + 2\alpha$ with respect to the vertical axis V, where α is the tilt angle of the surface 30 with respect to, e.g. a horizontal plane H. Accordingly, a reflected beam or ray 36 is deflected through an angle that is double the angle α moved by the surface 30. In the two-axis device, the mirror surface 30 has a second tilt angle in a plane perpendicular to the equatorial section shown in Fig. [~~3~~] 3A. The second tilt angle is not shown. Accordingly, an input ray 34 may be reflected at a reflection angle that may be any angle contained with a solid cone of angle centered on the rotation axis 32.

On page 12, please rewrite the first full paragraph as follows:

Integral to or attached to of the movable member 10 on the second side 8 thereof is a magnetic element 50 comprising a magnetic ring. The magnetic ring 50 is formed and attached to the ball 10 in a manner providing clearance between the ring 50 and the fixed member 40 for allowing the ball 10 to be rotated about the axis 32 through the angle α and a perpendicular tilt angle, not shown. Magnet ring 50 is made up of four magnet portions 50 a-d, an opposing pair of which, 50a and 50c are shown in the section view of Fig. [~~3~~] 3A. Each magnetic section comprises opposing north and south magnetic poles, labeled N and S respectively in Fig. [~~3~~] 3A and [~~7a-7d~~] 7A-7D, such that a magnetic flux passes through each magnet section from one pole to the opposing pole. According to the invention, opposing magnet portions, e.g. 50a and 50c have a south magnetic pole facing the ball 10 and a north magnetic pole facing away from the ball 10. Alternately, adjacent magnet section have oppositely oriented poles such that in the present example, magnet portions 50b and 50d have a north magnetic pole facing the ball 10 and a south magnetic pole facing away from the ball 10. The ring 50 may be assembled from substantially same sized magnet portions each forming a quarter portion of the ring 50 or the ring 50 may be formed as a single monolithic magnet. As will be detailed further below, the magnetic ring 50 may be formed integral with the ball 10.

On page 13, please rewrite the second full paragraph as follows:

The stator 70 further comprises stator current coils 60a-d, wound onto respective stator arms 70a-d, shown from side 8 in Fig. 4 and shown flat in Fig. 8. As shown in the cross-sectional Figure 3, opposing stator arms 70a and 70c and associated stator coils 60a and 60c are formed to substantially conform to the spherical shape of the ball 10 at a substantially uniform radius from the radial center 32 with distal ends of each stator arm 70a and 70c fitted into a recess 71 on an underside of the plate 40. Each stator arm 70a-d is fixedly <u>attached</u> to the fixed element or plate 40 by bonding, soldering or by any appropriate attachment method. Each stator coil 60a-d is wound to substantially perpendicularly intersect magnetic flux lines in the air gap 73, as will be further described below. As is shown in Fig. 8 the coils are wound perpendicularly to a longitudinal axis 74 of the stator arms 70a-d.

On pages 15 and 16, please rewrite the paragraph that joins pages 15 and 16 as follows:

Those skilled in the art will recognize that variations of the magnet configuration offer varied manufacturing solutions, some examples of which are shown in Figs. [~~7a-d~~] 7A-7D. For example the magnet portions 50a-d can be integral with the ball geometry as shown in Figs. [~~7a and 7c~~] 7A and 7C. In these configurations, the ball 10 may be removable from the fixed member 40 from the first side 6 without removing the magnetic element 50. This configuration is convenient if it is desirable to periodically replace the movable member 10 in the event of a damaged mirror or the like. A removable or permanent retaining collars 41, as shown in partial cross section in Fig. [~~7c~~] 7C. It may be added over ball 10, attached to the first side 6 of plate 40 to insure that ball 10 does not unintentionally escape from its seat. In other examples, the magnetic element 50 may be formed to extend outside the spherical form of the ball 10 as shown in Figs. [~~7b and 7d~~] 7B and 7D. In this configuration, the ball 10 cannot be removed from the fixed member 40 without removing the magnetic element 50. Accordingly, the magnet element 50 may further provide a retaining function for holding the ball in place in the event that a jarring shock for might cause the ball to dislodge from the bearing seat 20. In addition, the protruding edges of magnet ring 50 can also serve as a limit stop against the underside of plate 40 for limiting the tilt angles of the surface 30.

On page 16, please rewrite the first full paragraph as follows:

Figs. [~~7a and 7c~~] 7A and 7C further illustrate magnet configured with vertical magnetic pole orientations, while Figs. [~~7b and 7d~~] 7B and 7D illustrate magnet configurations with radial magnetic pole orientations. Any of the configurations may be used, however, the configuration shown in Fig. [~~7d~~] 7D is the preferred embodiment because it offers the most efficient use of its magnetic volume while providing radial magnetic lines across the air gap 73. Also, as best shown in Fig. 5, a magnetically permeable back iron element 81 may be formed integral with an otherwise non-magnetically permeable ball member 10 to provide a magnetic flux path as shown in Fig. 9. Of course numerous other magnetic circuit elements and flux paths are usable without deviation from the scope of the present invention.

On page 21, please rewrite the first full paragraph as follows:

In operation, the movable member 10 may be clamped in a fixed position for a long period without the need for applying any current to the coils 60 due to the clamping force provided by the magnetic element 50. This may allow the steering actuator 5 to direct an optical beam in a fixed [~~direct~~] direction or at a fixed target and hold the beam position for long periods with using electrical power and without generating heat in the coils 60. To reposition the surface 30 for [~~redirect~~] redirecting the optical beam to another orientation of target, a current may be applied to one or more of the coils 60 to induce a magnetic force in the stator 70. The magnetic force induced in the stator 70 acts on the magnetic element 50 to oppose F_{net}, thereby reducing or eliminating the torque force holding the ball in place. At the same time, the current in the coils 60 may be driven to rotate the movable member 10 in the raceway 20. The axis of rotation is coincident with a longitudinal axis of the stator 70. The rotation of the movable element tilts the mirror surface 30 for reflecting an incident beam at a new reflection angle. Once the desired position is acquired, the current is turned off, and the ball 10 is once again held in place by the friction torque force. Alternately, an additional clamping force may be applied by inducing a magnetic force in the stator 70 acting in the same direction as F_{net}.

On page 22, please rewrite the first full paragraph as follows:

Another position detection scheme applicable to these embodiments is illustrated on Figs. 15 and [~~16~~] 16A - 16C. Figure 15 depicts a beam steering apparatus 5, similar to that of Fig. [~~3~~] 3A, but further including an underside mirror 82 opposed to the mirror surface 30. A conduit 100 includes provides an optical channel for passing optical signals there through. A back plane substrate 42 is used to connect with the steering device 5 for providing and electrical interface to the steering device 5 via the electrical conduits 44. The conduit 100 also passes through the back plane 42 and may be supported thereby to maintain a rigid interface with the movable member 10. The ball 10 includes a chamber area 84 formed therein for providing a clearance between the conduit 100 and the ball 10 during rotation of the ball.

On page 23, please rewrite the first full paragraph as follows:

Fig. 15 shows the conduit 100 in detail. At a pick up end of the conduit 100 a pick up termination 102 is provided to bundle the conduits together in a fixed arrangement and to provide stiffness to the terminal end 102. Opposite to the terminal end, the conduits are separated into individual elements. A light source 93 is provided at one of the plurality of conduits at a termination 101 for delivering illumination to the mirror 82. Illumination from the light source 93 is delivered to the mirror surface 82 and reflected therefrom to the pickup termination 102. The end face of terminal 102 is shown in Fig. [~~16c~~] 16C. The reflected illumination from the mirror 82 is delivered to a radiation detector 92 via one or more of the plurality of optical conduits terminated at a detector termination 103. Fig. 16A shows the image conduit 100 connected by its pickup termination 102 at the pick up end and to the light source in Fig. [~~16b~~] 16B and to the radiation detector 92 in Fig. [~~16d~~] 16D.

On pages 30 and 31, please rewrite the paragraph that joins pages 30 and 31 as follows:

In another embodiment of the present invention, a single tilt axis device 700 is shown in Figure [~~3A~~] 3B. The single axis device 700 has a substantially identical cross-section as is shown for the device 5 in Figs [~~3~~] 3A and 5. However, the single axis device 700 includes a stator 702 having only one pair of opposing stator arms 702a and 702c and stator coils 704a and 704c. The single axis device 700 comprises two magnet elements 706 and 708. In this case a magnetic flux path extends across an air gap between the magnet 708 and the stator arm 702c, along the stator to the stator arm 702a, across a second air gap between stator arm 702a and the magnet 706 and through the cylindrical element 712. In the device 700, an elongated mirror surface 710 is formed onto a partial cylindrical 712. The magnets 706 and 708 are attached to the partial cylinder 712 and may extend along its full length or along only a portion of the length of the cylindrical element 712. Similarly, the stator 702 may extend along its full length or along only a portion of the length of the cylindrical element 712. The cylinder portion 712 is seated in a cylindrical bearing seat formed in a support plate 714. Accordingly the signal axis device may be used to scan an optical signal along a substantially one-dimensional line. One application of the device 700 may be to scan a scan line 716, incident on the mirror surface 710 such that the entire scan line is scanned through a range of angles.

On page 33, please rewrite the first full paragraph as follows:

Referring to Figure [~~24~~] <u>24A</u>, another scanning system 600 comprises a steering device 5 having a surface 30 according to the present invention. The surface 30 is selectively oriented in two axes by a current driver 602, includes a current driving circuit 400 as described above, according to the present invention. In this case, a radiation beam source 604 is attached directly to the surface 30 such that tilting of the surface 30 selectively adjusts a pointing direction of a radiation beam 606 emitted by the source 604. The device 600 may be used to direct the beam 606 onto a desired x and y location of a two-dimensional scan plane 608 or the device 600 may me used to scan a three-dimensional object with the beam 606. In addition, the device 600 may be used to point the beam 606 in a desired direction, e.g. at a far off target.

On page 34, please rewrite the first full paragraph as follows:

Another embodiment of a scanning system 600A is shown schematically in Figure [~~24A~~] 24B. The system 600A comprises a steering device 5A according to the present invention that is used to support a flexible radiation beam conduit 610 within a bore 612 that passes through the movable member or ball 10. According to the embodiment 600A, the flexible beam conduit 610, which may comprise a fiber optical element, is coupled at an input end 613 to a radiation source 614, e.g. a high-powered laser source, that delivers a radiation beam to the input end 613. A distal end 616 of the conduit 610 is supported within the bore 612 and the distal end 616 is movable with the ball 10 by the steering device 5A. A radiation beam 618 exits the conduit 610 at the distal end 616 and maybe pointed in a desired direction or at a scan plane 632, much like as in the system 600 described above. Similarly, a controller, not shown, may be used to control the pointing direction, receive feedback from position sensors and control the output amplitude and or wavelength of the radiation source 614.

On page 34, please rewrite the second full paragraph as follows:

In either of the embodiments 600 or 600A, a lens 630, shown schematically in Figure [~~24A~~] 24B only, may be positioned between the radiation beam, (606, 618), and the scan plane (608, 632). In either case, the lens 630 may comprise a telecentric lens, which is designed and positioned such that for each pointing direction of the radiation beam (606, 618), the lens 630 will direct the radiation beam to be incident onto the scan plane (608, 632) such that the beam is incident substantially perpendicular to the scan plane (608, 630). Accordingly, either of the scanning devices 600 and 600A when combined with the lens 630 may selectively address a plurality of discrete x and y points on the scan plane (608, 632) with an angle of incidence of the beam (606,618) that is substantially perpendicular to the scan plane surface (608, 632). This capability is readily applicable in laser processing devices e.g. in laser via drilling devices for drilling via holes in PCB's, in laser trimming device for trimming electronic circuit components, e.g. resistors and capacitors and circuit repair devices, e.g. for repair integrated circuits by laser ablation of selected portions of the circuit.